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THE RED PUMPKIN BEETLE, AULACOPHORA ABDOMINALIS FB. (*COLEOPTERA CHRYSOMELIDÆ*) AND ITS CONTROL; WITH A SHORT NOTE ON A. ATRIPENNIS, FB.

BY

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[Received for publication on 25th May 1925.]

I. INTRODUCTORY.

The most important vegetables cultivated during the summer in the Punjab belong to the Natural Order Cucurbitaceæ; one need only mention the very familiar gourds (*Lagenaria vulgaris*), pumpkins (*Cucurbita maxima*), *tindas* (*Citrullus vulgaris*, var. *fistulosus*), *ghia-tories* (*Luffa ægyptiaca*), and cucumbers (*Cucumis sativus*). In the vicinity of every town cucurbits are grown over large areas and every village has its plots of these vegetables. Further, melons and water-melons are the favourite fruits and extensive areas are put under these every year. In 1922-23, of the canal-irrigated land, 98,643 acres were under melons alone (18), and there is every year a much larger area of well-irrigated and *barani* (unirrigated) land under melons and water-melons.

The Red Pumpkin Beetle (*Aulacophora abdominalis*, Fb.) has proved a serious menace to the cultivated cucurbits and numerous complaints of extensive damage by the *bhoondi* have been received from practically every part of the Punjab. It is not only the cucurbit vegetables which are attacked but very often extensive fields of melons are entirely devastated. In one particular case a field of 4 acres had no more than 20 melon vines surviving an attack of this pest. The damage caused by the adult insect to the germinating or young crop is often so serious that

Figures within brackets in the text refer to bibliographical numbers at the end.

resowing becomes necessary, and if the sowing season is over the farmer has to face serious losses. Of the pests of vegetables in the Punjab, the Red Pumpkin Beetle is undoubtedly one of the greatest importance. The damage caused by this insect must run to tens of thousands of rupees every year.

Aulacophora abdominalis, Fb. has been known as a pest of cucurbits in India for a very long time. Surgeon-General E. Balfour (7) says : " A red beetle of Northern India is described in Mr. Firmenger's book on gardening as very destructive, " and this ' red beetle ' was most probably no other than the above mentioned species. Cotes (4, 5, 6) makes a definite mention of it as a pest. Lefroy (14) includes it in his " Indian Insect Pests," and in his " Indian Insect Life " (15, p. 362) he gives the following scanty information about this beetle :— " Though *A. foveicollis*, Kust., is extremely common, nothing is known of its life-history and all attempts to solve the problem hitherto have failed. It is a destructive insect to young cucurbitaceous plants, eating the leaves." Fletcher (7) records this insect as pest of cucurbits from Madras. A coloured plate of the various stages of this insect with a very brief account of its life-history, habits and control measures appeared in 1917 and according to Fletcher (8) ' it took five years to discover the mode of life of the early stages of this common insect '.

Such being the state of our knowledge of this very common pest of the Cucurbitaceæ all over India, a thorough study of this insect was regarded essential.

Casual observations on the life-history and habits were made during the last few years, but the problem was definitely taken in hand during May 1923 and observations were continued till May 1925. The results presented in this paper have thus been obtained after full two years' work.

The investigations were carried out at the Punjab Agricultural College, Lyallpur, and have been supplemented by information received from some other localities in the Punjab and facts ascertained at Pusa during the senior author's stay there. The work was carried out by the junior author under the guidance of the senior author and the former is mainly responsible for the data presented.

II. GENERAL.

It is interesting to note that of the Chrysomelid pests of cucurbits the most important belong to the two genera of the sub-family Galerucini. While *Diabrotica* spp. (particularly *D. vittata*, Fab.) are pests of cultivated cucurbitaceæ in America and some other parts of the New World (3), *Aulacophora* spp. devastate the plants of this natural order in the Old World. These two genera closely resemble in their structure, life-history and habits and yield to the same control measures.

The species of *Aulacophora* Chevr. which have been reported as pests during the last 12 years have been tabulated below. A perusal of this table will show

that most of the species mentioned are pre-eminently pests of the Cucurbitaceæ :—

Name	Food-plant	Locality	Reference to R.A.E.A. except those in figures.
Aulacophora sp.	Snake gourd	Ceylon	II, XII
A. abdominalis, Fb.	Young cucurbits	Mesopotamia, India	VIII (7, 8, 9)
A. atripennis, Fb.	Cucurbits and *patal*	South India, Bengal	(7, 8, 9)
A. cartereti, Guérin	Cucurbits	Queensland	II
A. coffeæ, Hornst.	Seed heads of lettuce	Philippines	I
	Cucurbits.	Do	V
A. fabricii	New Guinea Bean	Fiji	X
A. fabricii	Squash and pumpkins	Samoa	XII
A. femoralis, Mots.	Vegetables	Japan	I
A. hilaris, Boisd.	Cucurbits	Queensland	VIII
	"now attacks peaches, nectarines, cherries, apples."	New South Wales	V
	Cucurbits	Australia	IV
A. olivieri, Guérin.	Cucurbitaceæ, maize (leaves and silk).	Queensland, N. S. Wales.	II, VIII, VII
A. orientalis, Hornst.	*Melothria orgyea* and allied plants.	East Africa	XI
A. palmerstoni, Blackb.	Cucurbits	Australia	IV
A. similis, Oliv.	Mulberry (minor pest)	Formosa	VI
A. stevensi, Baly..	Cucurbits	South India, Ceylon, Burma.	(7, 8, 9)
A. wilsoni, Baly.	Cucurbits	Queensland	II

Attention is drawn to the fact that there exists considerable confusion regarding the species of *Aulacophora* and Junk in his recent Catalogue sinks into synonomy this generic name.

Only three species of *Aulacophora*,* Chevr. have so far been recorded from India as pests of cucurbitaceous plants. These species can be easily distinguished by their colouration, particularly that of the elytra :—

A. abdominalis, Fb. General colour orange-red dorsally, with orange-red elytra ; ventral surface of abdomen generally black.

*No work has so far been done on this genus and most probably many species occur in India.

A. atripennis, Fb. Head, prothorax and scutellum orange, elytra black; ventral surface orange.

A. stevensi, Baly. General colour same as in *A. abdominalis*, but with a well marked black stripe along the outer margin of the elytra, elytral suture black; ventral surface yellow.

Of the three species only the first two occur in Northern India and *A. abdominalis* is by far the commoner and consequently of greater importance. It is this species which is dealt with in the following pages.

III. *AULACOPHORA ABDOMINALIS*, FB.

1. Distribution.

A. abdominalis, Fb. has a very wide range of distribution, and has been recorded from localities mentioned in the following table:—

Locality	Food-plant	References
Europe—		
Shores of the Mediterranean Sea	....	(4)
Africa—		
Shores of the Mediterranean Sea	....	(4)
Sudan	Melons	(11)
Asia—		
Mesopotamia	Young cucurbits	R.A.E.(A.) VIII
India—		
Assam, Burma	All cucurbits	(9, 10)
Bengal, Hooghly, Dacca	Paddy (*Oryza sativa*[?]), Cucurbits	(4, 5, 6)
Bihar and Orissa	Cucurbits	(9, 10)
Central Provinces	Ditto	
Gwalior	Ditto	
Madras (throughout S. India up to 4,000 ft.).	Ditto	(7)
United Provinces, Saharanpur	Water caltrop (*Trapa bispinosa*)	(4, 5, 6) [see page 45]
Punjab (up to 6,000 ft. Kasauli)	Cucurbits	(2, 9, 10)
North-West Frontier Province	Ditto	(9, 10)
Andamans	Ditto	
Ceylon	Melon and other cucurbits	R.A.E.(A.) II, XI
Australia—		
Queensland	Ditto	(13)
Northern territory		
North Western Australia		
Aru		

In the Punjab this beetle is of common occurrence wherever cucurbits are grown, and every farmer and vegetable grower is familiar with the '*lal-bhoondi*' the 'red-beetle.'

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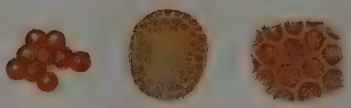

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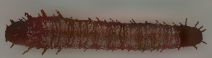

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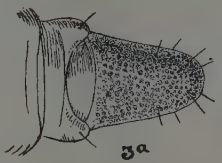

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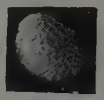

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4

6b

7

8

7ª

Explanation of Plate XII.

Aulacophora abdominalis, Fb.

1, Egg cluster enlarged.
1*a*, An egg much enlarged.
1*b*, Portion of egg further enlarged to show honey-comb sculpture on egg shell.
1*c*, Photograph of an egg enlarged.
2, Newly hatched larva.
3, Full grown larva.
3*a*, Anal shield dorsal view.
4, Pupa in pupal chamber.
4*a*, Pupa.
5, Female dorsal view.
5*a*, Female ventral view.
6, Male dorsal view.
6*a*, Male ventral view.
6*b*, Last visible sternum of male.

Aulacophora atripennis, Fb.

7, Male dorsal view.
7*a*, Male ventral view.
8, Damaged plants.

2. Description of various stages.

(1) Egg. (Pl. XII, figs. 1-1c). The eggs when laid singly are irregularly spherical, each measuring 0·612 mm. in diameter (average of 24 measurements) ; when laid in groups they are pressed against each other and become more or less polyhedral in outline. They are usually laid in a single layer in small batches, but sometimes a few may be laid over the first layer ; there is, however, no well defined arrangement. The freshly laid eggs are yellow in colour but turn orange after a short time. The egg-shell is sculptured with well marked ridges which meet each other, forming an irregular honey-comb-like structure (16). In a freshly laid egg the shell is soft and elastic, but turns hard and brittle on exposure to air.

(2) Larva. (Pl. XII, figs. 2, 3, 3a). A newly hatched larva is slender in form and of uniform thickness ; it is about 1·2 mm. long and about 0·28 mm. across the body ; the head is brownish in colour, and measures 0·3 mm. in length and 0·283 mm. across ; the antennæ are three-jointed. Prothorax is brownish dorsally and light-yellow ventrally and laterally. The rest of the body is creamy yellow in colour. The body is smooth except for the few long setæ that are present on the head and rest of the body. The last segment possesses a dark coloured anal shield marked with characteristic pittings and set with four pairs of long setæ. On the ventral side of this segment is a median, cylindrical process called " prop-leg " which is used by the larva in walking. Thoracic legs are light yellow in colour, and bear small hairs ; tarsi are unsegmented and each tarsus bears a single claw. A full grown larva measures about 12 mm. in length and 1·6 mm. across the body. The head is nearly as broad as long and is pale brown in colour ; the body is creamy white except the anal shield which is slightly darker.

(3) Pupa. (Pl. XII, figs. 4, 4a). The pupa is 6·5 to 7·5 mm. long and about 3·5 mm. across the mesothorax. The dorsum is convex and the pupa is slightly curved so that the head is pressed against the prosternum. Pronotum is rather large and broad and covers the head so that the latter becomes almost invisible from above. The antennæ lie curved up under the folded legs. The thoracic legs lie folded under the abdominal segments ; the third pair is covered over by the wings which are also folded under the abdominal region. Small brown setæ arising from tubercles are clearly visible.

Changes in the colour of the pupa. The eyes acquire blue-black colour and become prominent within 5-12 hours ; a yellowish tinge appears on the dorsal side of the head and thorax on the third or fourth day after pupation ; the colour of the elytra, changes at first into brownish black and then becomes slaty.

In the pupal chamber the pupa appears as if standing on its hinder end, and when disturbed, it jerks its body and spins rapidly round its axis in a characteristic manner.

(4) Adult. (Pl. XII, figs. 5, 5a, 6, 6a, 6b.) The adult is an elongate oblong beetle. The female (5·5-8·8 mm. in length and 2·3 to 3·5 mm. in breadth) is larger than the male, (5·5-8 mm. in length and 2·3 to 3·4 mm. in breadth). Its

general colour is brilliant orange-red, antennæ and legs are light orange and pygidium has the same colour as the elytra, metasternum and the ventral surface of the abdomen entirely black and clothed with silvery pubescence.

Head. Average length of head is 1·4 mm. and breadth 1·2 mm., surface smooth' vertex brilliant with reddish yellow colour ; clypeus yellow and somewhat convex, covered with brownish hairs all over ; antennæ light orange, eleven-jointed, basal joint being the largest and thickest particularly in male ; all joints pilose, the basal joint having the least number of hairs : compound eyes prominent, bulging and coal-black.

Thorax. The pronotum, nearly twice as broad as long, brilliant light orange in colour ; a transverse sulcus undulating in the middle runs across it, the lateral edges and part of the pronotum thickened and raised up, surface covered with minute punctures. Scutellum prominent, smooth and of brilliant orange-red colour. The elytra orange-red in female and light orange in the male, fine and close punctures present on the surface of the elytra.

Abdomen. Five abdominal segments distinctly visible ; the tergum of the last visible segment a triangular plate pointed in the female and obtuse in the male, the posterior margin of the last visible sternum notched in the female, and divided into three parts in the male, the middle portion being rectangular and having a longitudinal wide groove on it. The last abdominal sternum coloured black to nearly one-third of its anterior portion.

3. Life-history.

Beetles in copulation were brought from the fields and caged in deep glass dishes. About an inch of soil was placed at the bottom of each dish. The beetles fed and oviposited readily. It was found that for oviposition and successful rearing the soil in the dishes must be kept moist. The newly hatched grubs were provided with pieces of tender shoots, stems and roots of their food plants. They also fed quite readily on leaves and seemed to prefer those which were in course of decay. In most of the experiments, however, the decaying food was removed and grubs were fed on fresh material.

The beetles that had emerged in the laboratory were paired ; they copulated quite readily in captivity, and oviposited. Thus complete life-history was followed in many cases. As long as there was sufficient moisture in the cages the development went on successfully.

(1) Copulation. The duration of copulation, in captivity, was found to vary from 5 to 75 hours. The same pairs were noticed to copulate several times, the females laying a batch of eggs after each copulation. It was also noticed that one male was capable of copulating with a number of females at different times.

(2) Oviposition. Eggs were mostly laid during the night, and very few eggs were seen laid during day time. The females started oviposition a day or two after copulation but this varied with different individuals and in some cases eggs were

not laid till the seventh day after copulation. Oviposition is not continuous and generally there is an interval of two or three days between each laying.

Eggs may be laid singly or in batches. In the glass dishes, in the laboratory, they were laid on the surface of the moist soil or just below it, and occasionally on the leaves supplied as food. In the fields they were found laid on the surface of moist soil round the base of the food plants, in cracks or under small heaps of pellets of moist earth, but always in shady places.

The maximum number of eggs laid by a single female, in captivity, was 295 and the maximum number laid at one laying was 60. There are 24 to 30 egg-tubes in each ovary and it seems likely that at each laying not more than one egg is deposited from each egg-tubule. Examination of the ovaries also showed that only one egg developed at a time in each ovarian tubule. As the female lives over a month and egg laying continues all through, it is probable that a very large number of eggs is laid. From 29 to 240 eggs were found laid round one plant, and as there are possibilities of all hatching out, the losses caused by grubs must be considerable.

In the table below are given details about the oviposition of a few females :—

Statement of oviposition records of A. abdominalis, Fb. *in the Laboratory at Lyallpur during 1923 and 1924.*

Cage slip No.	Dates of Oviposition	No. of eggs laid	Total	Remarks
1923-5-13	22-5-23	25	125	Died on 28-5-23.
	25-5-23	50		
	26-5-23	50		
1923-7-11	24-7-23	60	176	Died on 3-8-23.
	26-7-23	60		
	1-8-23	6		
	3-8-23	50		
1923-7-31	7-8-23	60	84	Escaped on 13-8-23.
	10-8-23	10		
	11-8-23	2		
	12-8-23	12		
1924-3-21 b	23-3-24	52	152	Died on 11-4-24.
	25-3-24	36		
	28-3-24	19		
	31-3-24	27		
	2-4-24	18		
1924-3-23 b	25-3-24	20	106	Died on 21-4-24.
	4-4-24	17		
	6-4-24	23		
	14-4-24	39		
	20-4-24	7		
1924-3-23 b	25-3-24	8	199	Died on 4-5-24.
	28-3-24	18		
	1-4-24	6		
	4-4-24	21		

Statement of Oviposition records of A. abdominals, Fb. *in the Laboratory at Lyallpur during 1923 and 1924*—contd.

Cage slip No.	Date of Oviposition	No. of eggs laid	Total	Remarks
1924-3-23 c	9-4-24	25	199	Died on 4-5-24.
	13-4-24	24		
	16-4-24	20		
	20-4-24	37		
	23-4-24	10		
	25-4-24	30		
1924-3-21	28-3-24	17	80	Died on 5-5-24.
	31-3-24	21		
	4-4-24	7		
	6-4-24	3		
	11-4-24	5		
	13-4 24	20		
	14-4-24	7		
1924-3-21 c	28-3-24	43	99	Escaped on 10-4-24.
	1-3-24	33		
	5-4-24	3		
	6-4-24	5		
	7-4-24	9		
	8-4-24	2		
	9-4-24	4		
1924-3-23 a	28-3-24	35	149	Died on 25-4-24.
	3-4-24	22		
	9-4-24	24		
	13-4-24	22		
	16-4-24	33		
	20-4-24	13		
1924-3-19	1-4-24	17	64	Died on 21-4-24.
	2-4-24	3		
	16-4-24	17		
	18-4-24	17		
	21-4-24	10		
1924-3-23 e	4-4-24	22	167	Died on 15-5-24.
	13-4-24	14		
	16-4-24	13		
	20-4-24	22		
	25-4-24	10		
	29-4-24	17		
	1-5-24	4		
	4-5-24	26		
	11-5-24	39		
1924-10-28	31-10-24	10	295	This female was kept in the laboratory in a warm place and so continued laying, and did not enter into hibernation.
	1-11-24	16		
	3-11-24	50		
	5-11-24	50		
	8-11-24	58		
	13-11-24	46		
	20-11-24	32		
	7-12-24	5		Died on 8-12-24.
	8-12-24	28		

Factors influencing oviposition. In all experiments on oviposition it was noticed that eggs were readily laid on the surface of moist soil and whenever the soil was allowed to become dry oviposition stopped. Fertilized females kept in cages with dry soil rarely oviposited and eggs in such cases were laid invariably on green leaves supplied as food.

In April 1924 one gourd plant was covered over with a cage in the field and was not watered, so that the soil all round it was dry. Two pairs of beetles in copulation were introduced, the bettles lived for 15 days but not a single egg was laid. Two more pairs were introduced and these also laid no eggs.

Under natural conditions it was noticed that eggs were laid in large numbers just after the fields had been watered. This was particularly the case during May, June and July when in the Punjab the soil dries up rapidly. It was also observed that the fields which were regularly irrigated and kept well supplied with water had plenty of eggs laid on the moist soil, while the fields which were kept more or less dry had very few eggs. Eggs were sometimes laid in the glass tube in which beetles had been collected and in which humidity was very high.

The above facts clearly prove that a certain amount of moisture is essential for oviposition.

(3) Hatching. The eggs hatch out in about 6 to 15 days, duration of the egg stage depending mainly on temperature and humidity. A few hours before hatching the egg acquires a deep orange tinge and a shining appearance. The movements of the grub can be seen through the transparent shell. The grub cuts an irregular hole on one side and pushes its head out, and then by a violent jerking movement works its body free.

The eggs laid on the leaves in cages did not hatch out in any case, the leaves decayed and became mouldy and the eggs were also attacked by the mould. If the soil became dry after the eggs had been deposited such eggs did not hatch. This shows that a certain amount of moisture is necessary for proper development of the embryo. The excess of moisture, however, lowered the percentage of hatching and prolonged the egg stage. The following experiments performed during April 1924 throw light on the problem. In all cases the eggs were laid on moist soil in the glass dishes used for rearing :—

No.	Treatment	No. of eggs treated	No. of eggs hatched	Per cent. of hatching
1	Soil kept moist, eggs kept in shade . . .	183	183	100
2	Soil kept moist, eggs exposed to sun for 4 hours .	54	28	50
3	Eggs kept under water for two days, kept in shade	59	26	43
4	Eggs kept under water for two days and dried in sun	101	8	8
5	Eggs kept under water for two days and exposed to sun for 4 hours.	99	0	0
6	Soil kept dry after oviposition	92	5	5·4
7	Ditto ditto	221	0	0
8	Soil kept dry and eggs exposed to the sun for 4 hours	121	0	0
9	Eggs treated with a weak crude oil emulsion .	63	22	33

From the above it will appear that the most favourable conditions for hatching are moisture and shade. Exposure to the sun is harmful and so is prolonged submergence under water. In laboratory when the eggs were laid on moist soil in glass dishes and a proper degree of moisture was maintained the proportion of the eggs hatching was 73·6 per cent. (out of 691 eggs 509 hatched successfully).

(4) Larva. The newly hatched grub is quite active and moves about rapidly. It begins to feed upon roots and stems and bores into these. Later in the season the fruit is attacked, the larva boring into the fruit from the side lying on the ground. The larvæ cut holes in the leaves which lie on the soil and feed concealed under them. At the end of every instar the grubs enter the soil to moult and come out again to feed. Under favourable conditions and adequate food supply a grub becomes full grown and enters the prepupal stage within a fortnight after hatching, but the grub stage might last as long as 23 days. In fields the grubs are found in large numbers under surface of the soil round the roots of the cucurbitaceous plants, as also boring into roots, stems and fruits.

As the grubs enter the soil for moulting it is difficult to find out the number of instars. The measurement of the head was resorted to and grubs which were kept in glass dishes and supplied with pieces of gourd for food were taken out every day and measured. The width of the head was found to be :—

0·28 mm. for the first days.
0·40 mm. for the next 5 days.
0·58 mm. for the next 3 days.
0·63 mm. for the last 3 days.

Thus there are 4 larval instars. The duration of each instar varies with the food supply, temperature, etc., and the figures given above represent the time taken during March and April.

(5) Pupa. The larva when full grown leaves the surface and tunnels into the soil, where it prepares an oval chamber by moving its body round its longitudinal axis. The pupal chamber is quite smooth and appears to be lined with some secretion which makes it waterproof. It was noticed that even if water was kept standing for hours in a dish containing a pupal chamber, under only an inch of soil, the water could not enter the chamber. Even when feeding inside the fruit the larvæ leave it and enter the soil to pupate. Although hundreds of larvæ of various sizes were found inside the fruits no pupa was ever discovered.

The grub lies motionless in the pupal chamber, decreases in length and increases in thickness, and within 2 to 5 days it moults and changes into pupa.

In fields the pupæ were found in large numbers round the roots of the food plants. They were found to occur at any depth varying from ½″ to 10″. The pupal stage lasts from 7 to 17 days after which the adult emerges out.

To get some idea of the population of larvæ and pupæ one cubic foot of soil was removed from round the roots of each of the attacked creepers and on an average 50 pupæ and larvæ ready to pupate were found in it.

(6) ADULT. The adult beetle as it emerges is pale in colour but it soon develops its proper tinge. Soon after its emergence it begins to feed. Mating usually takes place at this stage and egg-laying commences in about a week's time.

(7) DURATION OF LIFE-CYCLE. The complete life-cycle—from the time the egg is deposited to the time the adult emerges—occupies from 32 to 55 days. The details of the various stages may be summarised as below. :—

1. Egg stage	6 to 15 days.
2. Larval stage	13 to 23 days.
3. Pupa stage	7 to 17 days.
4. Adult stage	The adults live for over a month, except during hibernation when they live for more than 5 or 6 months.

Statement showing the duration of various stages of Aulacophora abdominalis.

Serial No.	Date of oviposition	Date of hatching	Egg stage (days)	Date of pupation	Larval stage (days)	Date of emergence	Pupal stage (days)	Total duration of life cycle	No. and sex of beetle emerged
1	25-5-23	1-6-23	7	19-6-23	18	27-6-23	8	38	1♂
2	12-7-23	23-7-23	11	8-8-23	16	15-8-23	7	34	1♀
3	12-7-23	20-7-23	8	7-8-23	18	16-9-23		35	1♀
4	24-7-23	7-8-23	10	20-8-23	17	5-9-23	16	43	1♀
5	24-7-23	21-7-23	7	18-7-23	18	26-7-23	8	33	2♂
6	24-7-23	1-8-23	8	17-8-23	16	28-8-23	11	34	2♂
7	24-7-23	4-8-23	11	21-8-23	17	29-8-23	8	36	5♀
8	7-8-23	14-8-23	7	31-8-23	17	9-9-23	9	33	3♂
9	10-8-23	16-8-23	6	3-9-23	18	18-9-23	15	39	1♂
10	11-8-23	20-8-23	9	6-7-23	15	15-9-23	14	38	2♂
11	17-8-23	23-8-23	6	10-9-23	18	18-9-23	8	32	2♀
12	15-10-23	26-10-23	11	10-9-23	14	21-11-23	14	36	5♀ 3♂
13	29-3-24	6-4-24	14	..	..	12-5-24	..	50	1♂
14	25-3-24	8-4-24	14	1-5-24	23	17-5-24	16	53	1♀
15	25-3-24	5-4-24	11	..	..	12-5-24	..	51	1♂
16	28-3-24	9-4-24	12	..	..	14-5-24	..	47	1♀ 1♂
17	31-3-24	8-4-24	8	26-4-24	16	13-5-24	17	43	1♂
18	31-3-24	9-4-24	9	..	..	13-5-24	..	43	1♀
19	31-3-24	9-4-24	9	..	..	14-5-24	..	44	3♂
20	31-3-24	8-4-24	8	..	..	10-5-24	..	40	1♂
21	31-3-24	15-4-24	15	..	..	15-5-24	..	45	1♂
22	31-3-24	8-4-24	8	23-4-24	15	9-5-24	16	39	1♂
23	1-4-24	14-4-24	13	..	..	15-5-24	..	44	2♀
24	1-4-24	16-4-24	15	..	..	17-5-24	..	46	1♀ 3♂

Statement showing the duration of various stages of Aulacophora abdominalis—contd.

Serial No.	Date of oviposition	Date of hatching	Egg stage (days)	Date of pupation	Larval stage (days)	Date of emergence	Pupal stage (days)	Total duration of life cycle	No. and sex of beetle emerged
25	1-4-24	14-4-24	13	..	..	17-5-24	..	46	1♀ 4♂
26	1-4-24	16-4-24	15	..	..	17-5-24	..	46	1♀ 4♂
27	2-4-24	15-4-24	13	..	..	15-5-24	..	43	2♀
28	2-4-24	15-4-25	13	..	..	16-5-24	..	44	1♀
29	2-4-24	14-4-24	12	..	..	16-5-24	..	44	1♀ 1♂
30	2-4-24	15-4-24	13	..	..	17-5-24	..	45	1♀ 1♂
31	2-4-24	15-4-24	13	..	..	19-5-24	..	47	1♀
32	3-4-24	13-4-24	10	..	..	14-5-24	..	42	1♀ 2♂
33	3-4-24	13-4-24	10	..	..	15-5-24	..	43	1♀
34	3-4-24	13-4-24	10	..	..	16-5-24	..	43	1♀
35	5-4-24	16-4-24	11	..	..	16-5-24	..	41	1♀ 3♂
36	5-4-24	15-5-24	10	..	..	17-5-24	..	42	4♀ 7♂
37	5-4-24	16-4-24	11	..	..	19-5-24	..	44	1♀ 1♂
38	5-4-24	15-4-24	10	..	..	19-5-24	..	49	2♀ 5♂
39	6-4-24	16-4-24	10	..	..	8-5-24	..	32	1♂
40	8-4-24	19-4-24	11	..	..	23-5-24	..	45	1♂
41	..	14-4-24	..	30-4-24	..	15-5-24	15	..	1♀
42	9-4-24	17-4-24	8	8-5-24	21	23-5-24	15	44	1♀
43	16-4-24	25-4-24	9	..	..	28-5-24	..	42	1♀
44	23-4-24	30-4-24	7	..	..	2-6-24	..	39	1♀
45	24-4-24	3-5-24	9	..	..	2-6-24	..	38	1♀ 2♂
46	24-4-24	3-5-24	9	..	..	3-6-24	..	39	1♂
47	24-4-24	3-5-24	9	..	..	5-6-24	..	41	1♀ 3♂
48	25-4-24	3-5-24	8	21-5-24	18	5-6-24	15	41	1♂
49	26-4-24	5-5-24	9	..	..	3-6-24	..	39	1♂
50	26-4-24	5-5-24	9	..	..	5-6-24	..	41	2♂
51	2-5-24	9-5-24	7	22-5-24	13	7-6-24	16	36	1♀

4. Seasonal-History. (Pl. XIII).

(1) Time of appearance. The beetles begin to come out of hibernation in the beginning of March, or earlier if the temperature is favourable, and their number continues to increase, reaching the maximum about the middle of April. This brood entirely consists of the beetles which had emerged during the previous August and September and possibly October and had remained in hibernation during the cold season. By the end of April the beetles of this particular 'overwintered' brood begin to disappear, but thay have been depositing eggs during March (last

week) and April and large numbers of larvæ and pupæ can be seen during April and May.

(2) NUMBER OF GENERATIONS. The adults of the first spring brood begin to appear about the end of April and by the middle of May they are present in large numbers and reach their maximum strength about the end of May and beginning of June and continue to live till the beginning of July. By the middle of June the second brood begins to appear, and by the beginning of August the third brood makes its appearance. Thus by the end of August and beginning of September the adults of the second and third and not infrequently those of the fourth brood are present in the fields. Damage to the rainy season crop is mainly due to the beetles of these broods. There is a brood emerging in the beginning of September and the last brood appears about the middle of October. Thus there are five generations of these beetles during the year, but as the adults live for a considerable time and continue to lay eggs the broods greatly overlap. All the stages of the beetles are met with in the fields right from the beginning of April to the end of September or even middle of October. In October and November the adults begin to seek, shelter and their number falls. Early in November the beetles are seen feeding during the warmer part of the day only, and sit inactive concealed among leaves and creepers during mornings and evenings. Later in the season they are only found in their places of hibernation.

5. HIBERNATION.

(1) STAGE IN WHICH THE INSECT HIBERNATES. During the winter months the fields where the cucurbits had been growing and where the adult beetles, as well as, all the other stages of *A. abdominalis* were abundantly found, were carefully searched for eggs, larvæ and pupæ. No eggs were discovered but after prolonged search a few larvæ and pupæ were found. Thus it appears that in the Punjab, *A. abdominalis* hibernates in the adult stage, and the hibernating beetles most probably consist of individuals belonging to three or even four successive broods.

PERIOD OF HIBERNATION. From October onward the activities of the adult beetles become restricted and by November they enter into hibernation and remain in this condition till the beginning of March. Thus the majority of beetles remain in hibernation for over four months.

(2) PLACE OF HIBERNATION. The beetles hibernate, singly or in groups, usually among the curled up leaves and twigs of dried cucurbit creepers, but they readily take shelter among grasses, weeds, bushes, etc. During December, January and February they have been found hibernating in *Cana indica*, mulberry bushes, lucerne, brinjal, cotton, citrus, gram, cabbages, turnips and numerous weeds and grasses. In fact, any place that can provide safety from the severity of winter is availed of and often the adults are found in crevices in the soil. The uprooted cucurbit creepers or other plants which are usually piled on the boundaries of fields provide a very suitable shelter and are, therefore, a source of great danger.

(3) Proportion of sexes in hibernating beetles. A large number of beetles were collected at different times during the hibernation season and relative proportion of the sexes determined. Of 825 beetles collected during December 1923 and January 1924, 475 were females and 350 males, and of the 2,222 bettles collected during December 1924 and January and February 1925, 1,112 were females and 1,110 males. Thus the sexes hibernate almost in equal numbers.

(4) Mortality among hibernating beetles. The beetles collected during December 1924 to February 1925 were kept in wire gauze cages in the laboratory. On the 25th February it was found that about 67 per cent. of them had died and by the 3rd March, when a few beetles were seen flying about in the fields and the hibernation period was taken to be over, the proportion of survivors was no more than 25·3 per cent. Thus the mortality amongst the hibernating beetles was very high even in the laboratory where the temperature was higher than that prevailing outside in the fields.

To discover the condition under natural surroundings, 1,050 beetles were collected during October and placed in four wire gauze cages kept in the fields. Dried creepers with crumpled leaves were placed in these cages to provide shelter for the hibernating beetles. The results are given in the table below :—

	No. of beetles introduced	No. of beetles which survived hibernation
Cage No.		
1	300	90
2	500	75
3	150	30
4	100	20

Thus only 19·5 per cent. beetles survived.

Again a large number of beetles were introduced in wire gauze cages placed in the fields, but no shelter of any kind was provided, and it was found that of the numerous beetles introduced not one survived the winter. This clearly shows that mortality is very high during hibernation and without proper shelter the beetles succumb to cold. This demonstrates the importance of clean cultivation and of destroying every possible shelter for the hibernating beetles.

(5) Proportion of females fertilized before hibernation. Of the hibernating female beetles 49 were dissected during January 1924 and it was found that as many as 10 of these had been fertilized previous to hibernation and contained living sperms in their spermathecæ. During the winter of 1924-25, 400 beetles were dissected but only 25 contained sperms. From these figures it appears that in some cases at any rate copulation had taken place before the beetles hibernated, and these very likely belonged to third and fourth broods.

(6) PROPORTION OF SEXES AFTER HIBERNATION. As mentioned above the males and females hibernated in equal numbers and during the period of hibernation this proportion was maintained, but after hibernation a very large number of males died. Over 3,000 beetles were collected during the first fortnight of April 1925 and the relative proportion between males and females was found to be 1 : 6.

6. FOOD-PLANTS.

There exists some confusion regarding the food-plants of *Aulocophora abdominalis*, Fb. Cotes (4, 5) mentions it as destroying cotton, red gram, cucumber, *sanghara* (*Trapa bispinosa*) and paddy and summarizes the available information on *A. abdominalis* in the following : " 65. *Aulacophora abdominalis*, Fabr. A small yellow beetle, reported from Saharanpur as attacking Cucurbitaceæ of all kinds ; from elsewhere in the North-Western Provinces it has been reported as attacking water caltrop (*Trapa bispinosa*) ; from Ganjam it has been reported as attacking cotton (*Gossypium herbaceum*), gram (*Cicer arietinum*) and cucumber (*Cucumis sativus*) ; from Nuddea it has been reported as ' injurious to plants and vegetables '; while from Hooghly it has been reported as attacking paddy (*Oryza sativa*) " (6). Lefroy (14 p. 201) says, " The Red Pumpkin Beetle....is found attacking melons, gourds, cucumbers, and other cucurbitaceous plants. It is not limited to these plants, but is a common pest in gardens and in small patches of irrigated lands." Fletcher (8) states :—" *Aulacophora abdominalis* has been also noted on lucerne, but there seems to be some doubt about the identity of the species concerned and *A. abdominalis* is not a pest of lucerne as far as we know."

Evidently, therefore, either some other beetle has been confused with *A. abdominalis* or the mere presence of this insect on a plant has been regarded a sufficient proof of its guilt. The case of *Trapa bispinosa* is certainly that of mistaken identity, because the real pest of this plant *Galerucella singhara*, Lefroy, resembles closely *A. abdominalis* in general form and colour.

Specimens of adult beetles have been collected from different plants such as maize, gram, cabbage, egg plant, amaranthus, jute, sweet potato, turnips, mulberry, mango, citrus, guava, lucerne, shaftal, *Cana indica*, and a number of weeds and grasses, but in no case was any damage noticed. Actual experiments were tried and leaves of the plants given below were provided to the adult beetles kept in glass dishes in the laboratory. While the beetles provided with melon leaves ate their food voraciously, those provided with leaves of other than cucurbitaceous plants refused to eat and died of starvation.

Plants refused by *A. abdominalis* in captivity :

Coniferæ—*Pinus longifolia.*
Cannaceæ—*Canna indica.*
Cyperaceæ—*Cyperus tuberosus.*

Graminæ—*Triticum sativum; Hordeum vulgare; Avena sativa; Oryza sativa; Saccharum officinarum; Cynodon dactylon; Sorghum halepense.*
Palmaceæ—*Phœnix dactylifera.*
Leguminosæ—*Lens esculenta; Cicer arietinum; Lathyrus sativus; Trigonella faenum-graecum; Medicago sativa; Trifolium resupinatum; Trifolum alexandrinum; Meli'otus parviflora; Medicago denticulata; Lathyrus odoraties; Pisum sativum; Dalbergia sissoo; Acacia arabica; Acacia modesta; Albizzia labbeck.*
Cruciferæ—*Brassica campestris* var. sarson; *Brassica* var. Toria; *Eruca sativa; Cheiranthus cheiri; Iberis* sp.; *Brassica oleracea* var. botrytis; *Brassica oleracea; Brassica oleracea caulo-rapa; Brassica rapa; Raphanus sativus; Daucus carota.*
Malvaceæ—*Gossypium* sp.; *Hibiscus esculentus; Hibiscus Rosa-sinenis; Althea rosea; Malva parviflora;*
Chenopodiaceæ—*Chenopodium album; Chenopodium murale; Beta vulgaris* var. *orientalis.*
Amarantaceæ—*Digera arvensis.*
Solanaceæ—*Solanum tuberosum; Lycopersicum esculentum; Solanum melongena; Solanum nigrum; Capsicum frutescens.*
Rosaceæ—*Rosa indica; Eriobotrya japonica; Pyrus communis; Pyrus malus.*
Urticaceæ—*Ficus religiosa; Ficus indica; Ficus carica.*
Rutaceæ—*Citrus aurantium* var. Malta; *Citrus limonum; Citrus aurantium.*
Myrtaceæ—*Eugenia jambolana; Psidium guava; Punica granatum.*
Convolvulaceæ—*Convolvulus arvensis. Canvolvulus* sp.
Vitaceæ—*Ampelopsis hederacea. Vitis vinifera;*
Apocynaceæ—*Nerium oleander.*
Moraceæ—*Morus alba;*
Anacardiaceæ—*Mangifera indica.*
Cucurbitaceæ—*Momordica charantia.*
Asclepidaceæ—*Calotropis procera.*
Rhamnaceæ—*Zizyphus jujuba.*
Tiliaceæ—*Grewia asiatica.*
Boraginaceæ—*Cordia myxa; Helionopium supinum.*
Euphorbiaceæ—*Ricinus communis.*
Compositæ—*Lactuca sativa.*

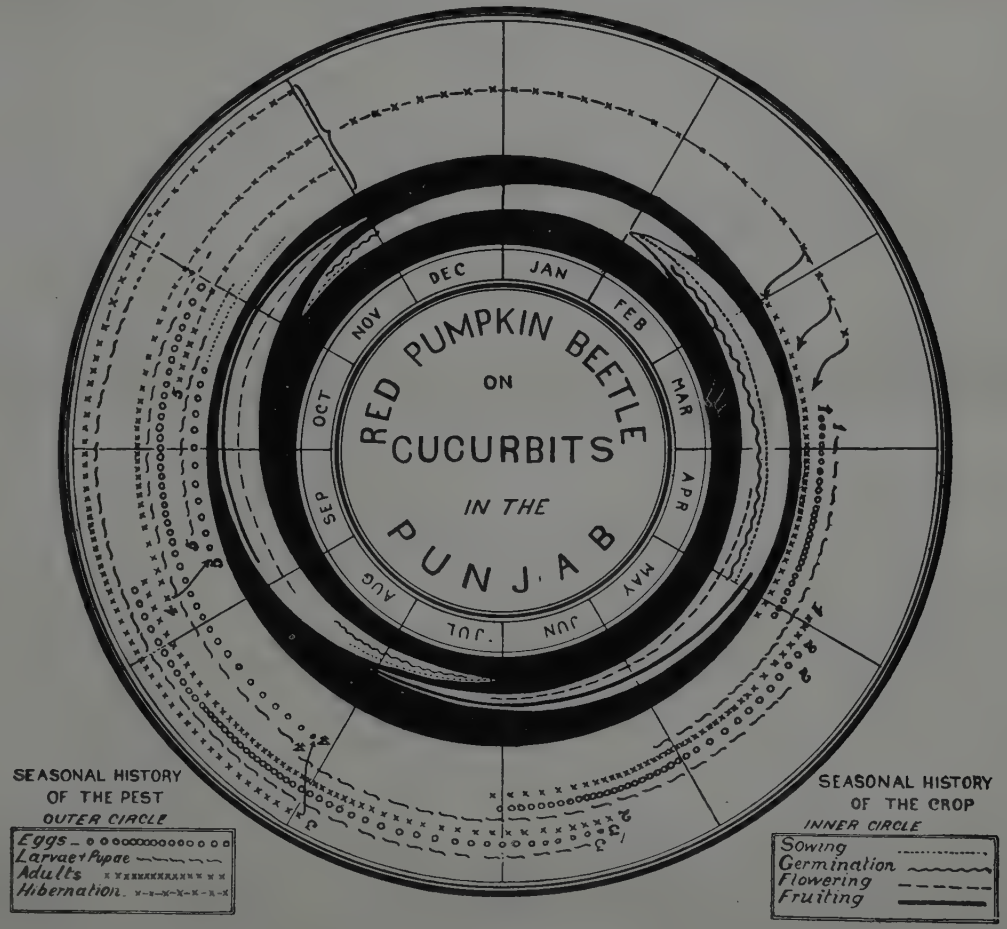
It was noticed that after a few days' starvation the beetles would nibble at and even eat a little of the leaves of:—

Lathyrus odoratus; Pisum sativum; Medicago sativa; Trifolium rempinatum; Oryza sativa; Zea mays;

but they could not live on these.

WHITE CRESCENTS ON BLACK GROUND INDICATE THE CROPS: FIGURES INDICATE EGGS, PUPÆ AND ADULTS OF VARIOUS BROODS,

PLATE XIII.



Till definite evidence is forthcoming it might be stated that *A. abdominalis* feeds exclusively on the plants belonging to the natural order Cucurbitaceæ, and at Lyallpur it has been known to feed on the plants given below :

Botanical name	Common English name	Vernacular name (Punjab)
Cucumis melo, Linn.	Musk Melon	Kharbuza.
Cucumis momordica, Roxb.	Melon	Phut, Khakhari.
Cucumis sativus, Linn.	Cucumber	Khera.
Cucumis utilissimus, Roxb.	....	Tar, Kakri.
Cucumis madraspatanus, Roxb.	....	Kachri, Chibbar.
Cucurbita maxima, W. & A.	Pumpkin vegetable marrow.	Halwa Kadu, Kanshi Phal.
Citrullus vulgaris, Schrad	Water melon	Tarbuz, Hindwana.
Citrullus vulgaris, Schard, var. *fistulosus*, Stocks	....	Tinda.
Benincasa cerifera, Savi	White gourd melon	Petha.
Lagenaria vulgaris, Seringe	Bottle gourd	Ghia, Kadu.
Luffa aegyptiaca, Mill.	Luffa, Spong gourd	Ghia, tori.
Luffa acutangula, Roxb.	Ribbed gourd	Mongi or kali tori.
Trichosanthes anguina, L.	Snake gourd	Chachinda.

All the three species of *Aulacophora* (pages 33-34) have been mentioned as pests of *Momordica* sp. in South India (7, 8, 9), but it must be pointed out that of the cultivated cucurbitaceæ *Momordica charantia* L. (Bitter gourd 'Karela') is not attacked by *A. abdominalis* and *A. atripennis*, and all attempts to feed adults on leaves of this plant have so far failed. This may be due to the presence of some unpalatable principle in this plant.

IV. SEASONAL-HISTORY OF THE CUCURBITACEOUS CROP. (Pl. XIII).

Usually two crops of cucurbits are grown in the Punjab ; the first crop is sown during February, March and April, and is the more important of the two. The second crop is put in about the end of June or the beginning of July, before the monsoons set in. In some cases, as for gourds, the first crop is over before the end of July but the same crop is ratooned and fresh vegetative growth starts during the rains. The growth of the plants is naturally very quick during and after the monsoons.

In neighbourhood of large towns the vegetable growers often sow an early crop of gourds, pumpkins, etc., in November, and erect a hedge of straw to reflect the rays of the sun on to the seed bed and germinating crop. Growth is very slow in winter but by the middle of March the plants are well developed and yield a very early crop of fruits in the beginning of April.

The spring sown crop begins to flower about the middle of April and fruiting starts about the end of April.

The crop sown before the rains germinates within three or four days and during the rains the growth is very vigorous. The flowers appear about the end of August and fruiting begins about the middle of September. Thus the food plants remain in the fields throughout the period of the activities of the beetles. (Pl. XIII).

V. DAMAGE.

The adult beetles feed on the leaves of cucurbits, and show special preference for the soft and tender ones (Pl. XII, fig. 8). In cases of severe attacks all the leaves of a seedling or a young creeper are completely eaten up and the defoliation is so thorough that the plants do not survive. In older vines, however, the beetles only eat holes in the leaves and as the vegetative growth is very vigorous and as broad leaves are produced in quick succession, the damage is never very serious. The greatest damage, therefore, is done to the germinating crop or young vines, and this is particularly true of the spring crop. The beetles come out of hibernation and become active about the time when the seeds sown in February are just germinating and each plant has two or three leaves which they eat up and the seedling is killed. In some cases not a single seedling of the first crop is left. The vegetable growers continue to put in seeds in place of the seedlings lost. This operation has to be repeated so often that in many cases it may safely be said that the whole field is sown three or four times.

The beetles of the second and third spring broods attack the second crop sown in the rains, but the damage done is not so serious as in the above mentioned case.

The special crop of gourds and pumpkins sown in November does not suffer so heavily because the vines are already well developed when the beetles appear after hibernation.

The adult beetles attack the flowers also and cause considerable loss of fruit.

The larvæ bore into the roots and stems and when present in large numbers they are responsible for the death of a large number of seedlings. The attacked plants wither and die. The observations in the field were confirmed by actual experiments in the laboratory. Seeds were planted in an earthen pot and allowed to germinate, and after a few days a number of freshly hatched grubs were placed in this pot. They at once started attacking the seedlings and ate up the portion just below the soil and the seedlings died within 15 days, and not one out of the 20 seedlings survived.

The grubs also bore into the fruit starting their attack at the portion resting on the ground. The fruit is marked and becomes unmarketable, or at any rate, does not fetch the same price as a sound one. At times the attacked portion becomes hard and discoloured. At Hoshiarpur and Jullandhar it was noticed that 2-5 per cent. of the fruits of water-melons, gourds, pumpkins, cucumber, etc., were marked. In the case of melons it has been noticed that the damage to the fruit is sometimes very serious, and up to 35 per cent. of the fruits may be marked, this is particularly true of the comparatively low lying places in the fields, where water stands for a longer period.

From the above it will appear that it is the adult stage which is responsible for the main damage and it is chiefly the beetles coming out of hibernation in the beginning of the Spring that cause the most serious losses. They appear in large numbers just when the crop is germinating and attack the young seedlings. As many as 20 beetles have been seen attacking a seedling with 3 or 4 leaves. Thus there is very little chance for the plant.

VI. CONTROL MEASURES.

The study of the seasonal-history of the pest in relation to the seasonal-history of the crop leads one to the conclusion that the beetles coming out of hibernation cause the greatest damage, as they appear at the time when the spring crop of cucurbits is just coming up. Moreover these beetles are the parents of the future broods which cause serious damage later on. It is, therefore, advisable to employ means of protecting the crop and destroying the pest at this stage. It will be clear, from what has been said above, that this pest can be effectively and economically dealt with only in the adult stage Therefore, the various methods of dealing with the adult beetle shall be discussed first.

1. Control measures against adult.

(1) Repellents. The practice of throwing ashes over germinating and young cucurbits, to protect them from the ravages of leaf eating insects, is common among the vegetable growers and farmers in India. Ashes act as repellent and there is no doubt that insects, to a certain extent, do avoid plants so treated, but in absence of other available food supply they usually overcome their abhorence and either select leaves free from dust or start their attack from the lower surface where the ashes have not reached. Addition of a little kerosene, however, improves the repellant properties of ashes. Other common substance which can be used for the purpose are dry slaked lime and tobacco dust. The latter has the additional value of being a very good manure. Lime and tobacco dust are usually diluted with ashes or road dust.

(2) Dusting stomach poisons. Repellents, however effective, are not of very great value. Insects repelled from the plants covered over with dust congre-

gate on to the plants not so treated and being present on fewer plants in large numbers cause very great damage. Further, as the repellents do not contribute towards reduction in the number of beetles any new leaves that appear are subjected to a very severe attack and considerable loss is the result. It is therefore, advisable that plants should be treated with some substance which will kill the beetles. Paris-green mixed with ashes or fine road dust, in the proportion of 1 : 8 by weight, was found to be the most effective of all the dusting powders tried. Paris green 1 : 32 or Lead arsenate 1 : 30 also gave very satisfactory results.

As the growth of the cucurbit plants is very rapid, particularly during the rainy season, experiments were performed to find out the duration of the efficacy of one dusting. A melon vine grown in a pot was selected and dusted over with Paris green and road dust (1 : 8) and covered over with a wire gauze cage. Beetles were introduced into the cage from time to time. It was noticed that the effect of a single dusting lasted for 5 days.

The cost of dusting one acre of melons for one month was also worked out. In all six dustings were given. For the first operation a stronger dose of poison was used (1 in 8 of road dust) so that the insects died after eating even a small quantity of the poisoned leaf. In subsequent dusting the proportion of Paris green was reduced to 1 in 32 of road dust. The cost of dusting one acre of melons six times comes to :—

	Rs.	A.	P.
One man for 12 hours at 12 annas per day of 8 hours	1	2	0
Paris green 9 chataks at Rs. 8 per seer	4	8	0
TOTAL .	5	10	0

One man can with the Feeny dusting machine cover an acre in 2 hours, and road dust costs nothing.

For efficient operation a dusting machine is essential but when one is not procurable an improvised dusting apparatus can be used fairly effectively. Any receptacle which is handy can serve the purpose (Pl. XIV, figs. 1, 5). Even small cheese cloth bags can be used. One operator can use two bags (fig. 4) at a time and by means of a simple contrivance, consisting of a pole to which the required number of bags is tied, more than two rows may be dusted at one time. While dusting a repellent or a poison mixture the following few points should be borne in mind :—

1. Dusting should always be done early in the morning on leaves wetted with dew.
2. The dust used must be very fine so that it adheres to the leaves.
3. As far as possible every part of the plant should be completely covered with dust. With the dusting machine this is done quite easily, but with an improvised apparatus it is rather difficult. Advantage can be taken of a slight breeze for blowing the dust in to the interior of the plant by jerking the bag a little away from the plant on the side from which the breeze is blowing.

1

Various vessels that can be used for dusting.

4

Dusting by means of chees cloth bags.

2

3

Dusting machine in operation.

5

Dusting with one of the vessels shown in 1.

PLATE XIV.

4. Dusting should be repeated after every shower of rain.
5. Dusting should not be attempted on a windy day.

(3) SPRAYING. If a spraying machine is available any of the well known stomach poison may be sprayed. The following insecticides may be tried :—

1. Lead arsenate mixture—

Lead arsenate	1	part	by weight.
Lime	3	parts	,,
Molasses	6	,,	,,
Water	600	,,	,,

2. Tobacco decoction—

Tobacco (refuse)	6	,,	,,
Soap	1½	,,	,,
Water	600	,,	,,

Spraying should be done before the attack begins and repeated every six days for the first month.

(4) HAND PICKING OR COLLECTING WITH HAND NETS. If nothing else can be done the beetles may be hand picked. This gives excellent results particularly in the beginning of the season when plants are young and beetles are not so numerous. This operation should be performed in the mornings when the temperature is low and beetles are sluggish, as is the case in March in the Punjab. During warmer parts of the day hand nets may be tried. These simple operations should not be neglected, particularly over small areas. Rapid increase in the number of beetles is prevented and chances of severe losses are greatly minimised

When beetles are present in large numbers on young plants they can be easily collected by shaking them into shallow pans containing water and kerosene. This should be done during the cooler part of the day, preferably morning. In one particular experiment 9,273 beetles were destroyed, from a melon field of two acres by one man working 3 hours a day on three successive days. He worked for one hour each time, morning, noon and evening. The largest number of beetles were taken in the mornings, and fewest at midday. The results are tabulated below :—

Date	Time	Beetles collected	TOTAL
10th April 1925	Morning	2,000	
	Noon	100	
	Evening	547	2,647
11th April 1925	Morning	3,541	
	Noon	142	
	Evening	900	4,583
12th April 1925	Morning	1,237	
	Noon	76	
	Evening	730	2,043
			9,273

(5) Trap crop. A few plants of some cucurbit should be planted early so that they are well above the ground when beetles come out of hibernation and they should be dusted with a strong dose of stomach poison. The beetles coming out will feed on these and shall get poisoned or they can be dealt with in some other effective manner. Similarly when the rainy season crop is being removed a few vines should be kept and dusted with strong poison. The beetles before going into hibernation will collect on these plants and eat the poisoned leaves and die.

2. Control measures against grubs and pupæ.

(1) Soil fumigation. Various experiments with carbon bisulphide, petrol and kerosene were tried but it was found that soil fumigation was not an economic proposition. If, however, it is necessary to kill the grubs this can be done most cheaply by pouring strong tobacco decoction round the roots of the plants.

(2) Flooding the fields. Flooding the fields besides being harmful to the crop was not effective in killing grubs and pupæ. A field two '*marlas*' in area was flooded for two consecutive days and it was found that the mortality among the grubs was not higher than 5 per cent. and the pupæ were all safe. Heavy rains did not have any evil effect on the pest. In a particular instance it rained heavily in August for two days and yet observations taken after the rains showed that the larvæ and pupæ did not suffer much.

(3) Ploughing the field after the crop. The only satisfactory method of destroying the pest in its grub or pupa stage is to plough the fields after the spring crop is harvested. This operation exposes grubs and pupæ, which are greedily devoured by crows and other birds. It must be borne in mind that a very large number of grubs and pupæ remain in the clods and thus escape destruction. Clods should, therefore, be broken by means of *sohaga*. It was, however, found that some of the grubs and pupæ escaped injury even after the clods had been broken, and remained concealed being covered over with soil. It is, therefore, essential that ploughing should be thorough, and the field should be harrowed once or twice.

3. Clean cultivation.

Crop remnants are a veritable source of every kind of plant disease. Cultivators should make it a point to keep their fields free of all rubbish, and dead plants. It is a common practice with farmers and vegetable growers to leave cucurbit creepers in the fields after the crop has been harvested. During summer these creepers provide food for the grubs which feed on the roots, stems, rotten leaves and even fruits and they also produce good crop of leaves for the adults. During winter the dried up creepers provide an excellent shelter for the hibernating beetles. It is, therefore, essential that after the spring crop is over the creepers should be pulled out and destroyed, and the fields ploughed up and harrowed, so as to expose grubs and pupæ. The creepers of the rainy season crop may be left in the field till Nov.

ember and then pulled out and collected at one place ; and, when the beetles have taken refuge in them for hibernation, this heap of creepers should be covered over with straw and set on fire. In some cases it was noticed that the beetles flew out of this smouldering heap. To guard against this it is necessary to cover the heap with plenty of straw so that the beetles cannot find an easy exit.

Further all places where beetles find shelter for hibernation should be dealt with. Ploughing the fields and safe disposal of crop remnants if done systematically will save the farmer from the ravages of a large number of crop pests including *A. abdominalis*.

4. Use of manures and fertilizers.

Very often a vigorous growing plant outgrows even a severe attack of a pest and if manures and fertilizers are used to stimulate growth in cucurbits, the serious consequences of beetle attack can be overcome.

5. Sowing early varieties.

It has been mentioned above that the beetles come out of hibernation about the beginning of March and if by then the plants are well established the damage done is not serious. It is therefore advisable to sow early varieties or to sow ordinary varieties early so that the creepers have plenty of leaf before the beetles appear.

6. Growing excess of seed.

As mentioned above, the cucurbit crops have often to be sown twice, thrice or even four times because of the attack of the Red Pumpkin Beetle. The farmers usually put in a seed in the place of a seedling lost and very often this continues for so long a time that proper sowing season is over. Sometimes excess of seed is sown but then three or four seeds are put in together in the same place at the same time, and all the seedlings which must come up together meet the same fate and are eaten by the beetles; therefore, from entomological point of view, it is no gain. It has been suggested that the seeds should be sown in groups of four during the four successive weeks, every seed being put in each week in the following manner— $\frac{1}{3}\Big|\frac{2}{4}$. Thus seeds will germinate with a week's interval between each sowing and there are chances of at least one out of the four seedlings remaining safe. If the crop is too thick it can be thinned later on. If required the first crop can be used as a trap crop. This system will ensure a crop without unnecessary delay (3).

7. Covering the germinating and young plants.

In some countries the germinating and young plants are covered with cheap wire gauze covers of various designs (3). This is a very useful device for a small plot and for those who grow vegetables for the market, because these covers can be used for protecting other vegetables, seed beds, etc.

8. Hanging crumpled paper.

It has been stated that if a crumpled paper is hung over the plants, it is kept dangling by the breeze and beetles get frightened and do not attack the plant (16). This was not found very effective at Lyallpur.

9. Natural enemies.

Except crows, 'mynas' and some other birds, which pick up grubs and pupæ when they are exposed by ploughing or harrowing, no predators and parasites have so far been noticed.

It has, however, been found that adult beetles often contain large numbers of gregarian parasites in the alimentary tract, but these do not seem to have any evil influence on their host (2). Certain mites have also been seen on the bodies of these insects.

VII. *AULACOPHORA ATRIPENNIS*, FB. (Pl. XII, figs. 7, 7*a*).

With the Red Pumpkin Beetle (*A. abdominalis*) there occurs another species *A. atripennis*, Fb. (*excavata*, Baly) which can be easily distinguished from the former by its black elytra. It is never present in such large number as *A. abdominalis*.

In its habits and life-history it very much resembles *A. abdominalis*. Although it has been definitely mentioned as a pest of "all cucurbitaceous plants" (7) particularly *Cucurbita*, *Cucumis* and *Citrullus* (8), yet at Lyallpur, in fields, it is known to feed only on *Luffa ægyptiaca* and *L. acutangula*. This was confirmed by experimental evidence. Adult beetles were confined in glass cages and supplied with leaves of *Laginaria vulgaris*, *Cucumis sativus*, *Citrellus vulgaris*, *Benincasa cerifera*. *Citrullus vulgaris* var. *fistulosus Cucumis melo* var. *utilissmia*, *Memordica charantia*, and *Tri- chosanthes anguina*, but they refused to eat them and died of starvation Leaves of *Cucumis melo*, and *Cucurbita maxima* and in some cases those of *T. anguina* were, however, eaten after two days' starvation. In the control cages where leaves of *Luffa aegyptiaca* and *L. acutangula* were supplied the beetles continued to feed all through the experiment. The above trials of food plants were repeated twice with exactly the same results.

In another experiment a leaf of each of the above mentioned cucurbits was placed in a dish and a number of beetles introduced; on the second day it was noticed that while the leaf of *Luffa aegyptiaca* was completely eaten the leaves of all the other cucurbits were not touched.

The following common cultivated plants were also tried, but the beetles did not eat any of these :—

Gramineæ—*Oryza sativa*, *Zea mays*, *Saccharum officinarum*, and *Andropogon sorghum*, *Pennisetum typhoideum*.

Leguminosæ—*Medicago sativa*; *Trifolium resupinatum*.

Malvaceæ—*Gossypium* sp., *Hibiscus esculentus.*
Solanaceæ—*Solanum tuberosum ; S. melongena, capsicum frutescens.*
Convolvulaceæ—Iporiœa batatus.

VIII. SUMMARY.

Aulacophora abdominalis, Fb. has a very wide distribution. It has been reported from both the shores of the Mediterranean, Sudan, Ceylon, Mesopotamia, Australia and occurs all over India.

In the Punjab it attacks all the cultivated cucurbits (except *Momordica charantia*) and does extensive damage.

The life-history may be briefly summarised as follows :—

Small, rounded, yellow eggs are laid on moist soil round the base of the food plant. The egg stage lasts from 6—15 days. The small, whitish larvæ as they come out of the egg bore into roots, stems and fruits, and also feed on leaves lying on the soil. In 13—23 days larva becomes full grown and enters the soil to pupate in an oval chamber which is made impervious to water by some sort of secretion. The pupal stage lasts from 7—17 days. The adults live for about a month (except those that hibernate) which live for over 5 months and continue to feed and lay eggs. There are 5 generations during the year. The adults *A. abdominalis* are orange red in colour and *A. atripennis* have black elytra.

Adult beetles hibernate under old cucurbitaceous creepers, among bushes, grasses and weeds and even in crevices in the soil, and remain in this condition from the middle of October to the beginning of March.

The beetles become active during March and April and continue to feed on leaves, eat up the tender leaves of the germinating or young cucurbits and so completely defoliate them that the entire crop is lost, and sometimes the seed has to be sown three or four times. The beetles lay eggs on moist soil, round the bases of cucurbitaceous plants, and the larvæon hatching out enter the roots and stems and kill the seedlings thus adding to the damage caused by the beetles.

Beetles of the next broods do comparatively little damage because the creepers are well developed and growth is so rapid that loss of leaves eaten is made good very soon. The beetles of the second and third spring generations are mainly responsible for the attack on the July sown cucurbits.

Larvæ although far less destructive than adults often cause serious losses by boring into the roots and stems of seedlings and young plants, and by marking the fruits.

As the beetles coming out of hibernation in the spring are most destructive and are the source of future evil, efforts should be made to deal with them. Use of repellents is effective in saving the plants, and ashes, slaked lime or road dust may be used mixed with tobacco dust or kerosene.

Stomach poisons, however, give better results as they kill the insects. Paris green, or Lead arsenate may be dusted or sprayed. Tobacco decoction has also given good results. Dusting or spraying must be repeated every 5th or 6th day so that the new leaves are covered.

It is recommended that a few early plants be grown to serve as a trap crop. The beetles as they come out of hibernation will be attracted to these and can then be killed by the use of some stomach poison or contact poison. This trap crop may also be used for attracting the beetles to a few plants for hand picking. Hand picking during colder parts of the day gives good results.

Ploughing the fields, after the spring crop has been harvested, is effective against the larvæ and pupæ as these are exposed to the sun and are also readily picked up by birds. Ploughing must be thorough and the clods should be broken, and harrowing should be done once or twice.

Clean cultivation should be insisted upon and all old creepers, grasses, bushes, etc., which serve as shelter for the hibernating beetles should be destroyed. Collecting creepers in November and keeping them till such time that most of the hibernating beetles have gathered on them and then setting them on fire would help to destroy the adults.

Early varieties if obtainable should be sown, and their growth stimulated by use of manures so that by the time adults come out of hibernation the plants are well established and have sufficient of leaf to withstand attack or outgrow it.

The practice of sowing four seeds close together during four successive weeks ensures a crop and should be tried.

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